CE Workgroup

Embedded Linux Community Update

December 2019

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Architecture Group Chair, Core Embedded Linux Project

Nature of this talk…

- Quick overview of lots of embedded topics
- A springboard for further research
  - If you see something interesting, you have a link or something to search for
- Not comprehensive!
  - Just stuff that I saw

Outline

Operating Systems
Linux Kernel
Technology Areas
Conferences
Industry News
Resources

Outline

Operating Systems

Linux Kernel

Technology Areas

Conferences

Industry News

Resources

Operating Systems

- NuttX
- Zephyr
- Android
- Linux

NuttX

- NuttX continues to grow in support
  - SMP
  - WiFi
- I saw a demo of NuttX on SiFive RiscV processor this week.
- More companies are using it
  - Sony using on SPRESENCE board
    - With supporting code already upstream!

NuttX events

- Had a meetup in October
  - NuttX workshop
    - In Lyon, France, October 31
- Also, some NuttX content at ELCE
  - NuttX for Linux developers – Masayuki Ishikawa
- More NuttX conferences in 2020
  - In Japan!
  - January meetup at Sony Headquarters
  - NuttX International Conference – May 13-15
    - Sponsored by Sony, in Tokyo

Zephyr

- Support for AMP and SMP
- See ELCE talk: “Multicore Application Development with Zephyr RTOS” by Alexey Brodkin
  - https://elinux.org/images/e/e5/Multi-core_application_development_with_Zephyr_RTOS_-_2019.10.23.pdf

Android

- Android 10 (‘Q’ version) was released on September 3, 2019
- Some features:
  - New gestures for navigation
  - Floating settings panel
  - Dynamic depth format for photos
    - Google pushing new photo file format that encodes depth
  - AV1, HRD10+ and Opus codecs
  - Support for foldable phones
  - “Bubbles” multi-tasking feature

Android

- Android 10
  - By tradition: ‘Q’ version
  - No more letters or dessert names! (publicly)

Outline

Operating Systems

Linux Kernel

Technology Areas

Conferences

Industry News

Resources

Kernel Versions

- Linux v5.0 – 3 Mar 2019 – 71 days
- Linux v5.1 – 5 May 2019 – 63 days
- Linux v5.2 – 7 Jul 2019 – 63 days
- Linux v5.3 – 15 Sep 2019 – 70 days
- Linux v5.4 – 24 Nov 2019 – 70 days
- Current kernel = v5.5-rc1
  - Merge window is closed – no new features for 5.5

Linux v5.0

- Energy-aware scheduling
- Legacy block layer IO scheduler removed
- Binderfs – backward-compatible filesystem for Android's binder IPC mechanism
- Adiantum crypto module
- JSON schemas for device-tree bindings
  - https://lwn.net/Articles/771621/

Linux v5.1

- Deprecating support for a.out binaries
  - https://www.phoronix.com/scan.php?page=news_item&px=Linux-Dropping-A.Out
  - Use ELF from now on
- Lots of DRM changes
  - https://www.phoronix.com/scan.php?page=news_item&px=Linux-5.1-DRM-Changes
- More Y2038 work
  - More syscalls with 64-bit time values
    - See https://git.kernel.org/pub/scm/linux/kernel/git/torvalds/linux.git/commit/?id=b1b988a6a035 for a list of new syscalls (20 of them)

Linux v5.1 (cont.)

- Energy-Aware scheduling
  - New sysctl knob (/sys/kernel/sched_energy_aware)
  - Documentation/scheduler/sched-energy.txt
  - Documentation/power/energy-model.txt
- Improved idle behavior in tickless systems
  - Added timer-events oriented (TEO) CPU-idle governor
    - Uses timer interrupts timing instead of device interrupt timing for predicting next wake-up
  - See https://lwn.net/Articles/775618/

Linux v5.1 (cont1.)

- Modification to memfd for Android use case
  - Add F_SEAL_FUTURE_WRITE operation for memfd regions
    - Caller can continue to write to region, but others can’t
  - Want to eliminate use of ashmem (legacy Android memory manager)
- F2FS has a new mode bit that disables copy-on-write behavior for a file (F2FS_NOCOW_FL)

Linux v5.2

- ext4 supports case-insensitive lookups
- New system calls for filesystem mounting
  - See https://lwn.net/Articles/759499/
- Support for ARM Mali GPUS
- Support for Fieldbus protocol
- New “mitigations=“ command-line option to control speculative execution features
- Improved support for gcc ‘-Wimplicit-fallthrough’
- Lots of BPF improvements

Linux v5.2 (cont.)

- Pressure stall monitors added
  - Allow user-space to detect and respond quickly to memory pressure
  - Monitor can open /proc/pressure/memory and write a stall notification specification
    - indicates to the kernel what frequency to check for stalls (which can be as little as .5 seconds)
  - Monitor can then use poll() to receive stall notification events
  - Android can use the functionality to detect mounting memory pressure and kill processes before the device becomes sluggish
  - See https://lwn.net/Articles/775971/

Linux v5.3

- New pidfd feature – to handle pid reuse
- Scheduler utilization clamping
  - (see next slide)
- 0.0.0/8 IPv4 address support
  - Allows 16 million new IPv4 addresses
- Added CONFIG_PREEMPT_RT
  - But not the final code yet
- init_on_alloc and init_on_free boot options
  - pre/post-initialize memory from heap allocations
- See https://kernelnewbies.org/Linux_5.3

Scheduler utilization clamping

- Extension to Energy Aware Scheduling
- Allows specifying minimum or maximum frequency for a process
- Can clamp user-visible (foreground) tasks to high minimum frequency
- Can clamp background tasks to low maximum frequency
- Helps conserve power while still keeping responsiveness
- See https://lwn.net/Articles/762043/

v5.3 last minute revert

- Last-minute revert of useful patch
  - Improved ext4 performance by reducing needed disk I/Os
  - So much, that not enough entropy was generated on boot
  - Causing an end-user system to not boot
    - System hung on get_random()
- All new end-user failures are regressions
  - “No regresions” is the kernel’s “First rule”
- Have to work out how to add new feature without breaking end users
- See https://lwn.net/Articles/799249

Linux v5.4

- EROFS graduated from staging
- exFAT added to staging
- fs-verity feature added
- boot-time entropy fix
  - Fix for commit that was reverted in late 5.3
  - Prevents get_random() from blocking on boot
  - Implementation based on clock jitter, by Linus himself
  - See https://lwn.net/Articles/802360/

Linux v5.5

- ARM64 has full support for ftrace
- MIPS supports kcov – coverage analysis
- KUnit testing framework added
- CPU scheduler's load-balancing algorithm was replaced
  - Follow-on to PELT (Per Entity Load Tracking) work
    - See https://lwn.net/Articles/732021/ for PELT info
- sysctl() system call was removed
  - Use /proc/sys/... instead

Contributions for recent kernels

Version	Changesets	Developers
4.15	14,866	1801
4.16	13,630	1805
4.17	13,541	1713
4.18	13,283	1728
4.19	14,043	1752
4.20	13,884	1749
5.0	12,808	1757
5.1	13,304	1737
5.2	14,024	1783
5.3	14,435	1846

Source: https://lwn.net/Articles/798505/

Interesting stats

- 256 new contributors
  - Developers who have never contributed before
- 3 of the top 5 “reported-by” lines for bugfixes are for automated testing systems
- At least 14% of commits are fixes for bugs
- See https://lwn.net/Articles/798505/

Outline

Operating Systems
Linux Kernel
Technology Areas
Conferences
Industry News
Resources

Technology Areas

- Audio
- Graphics
- Kernel coding
- Languages
- Networking
- Security
- Testing
- Tracing

Audio

- NVIDIA submitted patches to ALSA project for their hardware to work with the DisplayPort Multi-Stream Transport (DP-MST) audio
  - Added DP-MST jack support
  - Support for non-acomp codecs
  - Support for HDA HDMI audio driver
- Should work in upcoming Linux 5.5 cycle
- See https://www.phoronix.com/scan.php?page=news_item&px=NVIDIA-DP-MST-Audio-Linux-5.5

Graphics

- NVidia providing support for Nouveau driver development
  - Provided much-needed docs in August
    - See https://www.techradar.com/news/nvidia-gives-a-major-boost-to-nouveau-open-source-driver-for-linux
  - May be more in the future
    - Nvidia has a talk titled “Open Source, Linux Kernel, and NVIDIA” at GTC (GPU Tech. Conf.) in January 2020
- Mesa 19.3 release
  - Is coming very soon (possibly this week)
  - Includes lots of Open-Source OpenGL support
  - Vulkan driver improvements
  - See https://www.phoronix.com/scan.php?page=article&item=mesa-193-features

Kernel coding

- Support for –Wimplicit-fallthrough
  - Warns about possible switch statement error (missing break in a case block)
  - Used to make switch statements more robust
    - See https://dzone.com/articles/implicit-fallthrough-in-gcc-7 for info about gcc feature
  - v5.2 marked locations where one case in a switch statement can fall through to the next case
    - Extensive analysis of kernel – only 32 out of 2311 cases remained to be fixed
  - v5.3 turned on warning by default
    - Now catch fall-through errors in newly submitted code

Languages (Python)

- Python has become dominant in Machine Learning and AI
  - See https://www.analyticsindiamag.com/5-reasons-why-python-is-the-dominant-language-for-machine-learning/
- Growing in popularity
  - https://www.zdnet.com/article/which-programming-languages-are-most-popular-and-what-does-that-even-mean/

Python (cont.)

- Python 2 to be unsupported on Jan 1, 2020
  - See https://pythonclock.org

- There are lots of resource to help with conversion to Python 3
  - “2to3” tool, online guides, etc.

Languages (C/C++)

- gcc 9
  - 9.2 released August 12, 2019
  - Removal of Cell Broadband Engine SPU support
  - New ‘-flive-patching’ flag
  - Lots of diagnostics improvements
    - Can show line numbers in diagnostic source code
    - Can show source code region labels
    - Can output diagnostic information in json format
  - Optimization improvements
    - New options for profile-driven optimization
    - Link-time optimization (LTO) improvements
  - See https://gcc.gnu.org/gcc-9/changes.html

Languages (C/C++ cont.)

- LLVM 8.0 release (19 July, 2019)
  - Features:
    - Speculative Load Hardening (for Spectre issues)
    - Branch Target Identification (for Spectre issues)
    - Improved code diagnostics
  - https://www.phoronix.com/scan.php?page=news_item&px=LLVM-Clang-8.0-Branch-Next-Week
- LLVM 9.0 release (19 Sep. 2019)
  - JITLink
  - Time trace profiling data
  - https://www.phoronix.com/scan.php?page=news_item&px=LLVM-9.0-Clang-9.0-Features

Networking

- iwd (Inet Wireless Daemon) 1.0 released!
  - Intended replacement for WPA Supplicant for managing WiFI connections
  - Goals are:
    - Easier WiFi configuration for users
    - Faster connection setup (100 ms)
  - See “iwd – State of the Union” by Marcel Holtmann at ELCE 2019
- For a good overview of wireless specs:
  - See” Understanding Wi-Fi Variants” by Mike Anderson at ELC 2019

Security

- Big security vulnerability for Linux VPN found
  - Just announced a few days ago
  - Allows attacker to hijack a VPN connection
    - By deducing the TCP packet number
  - Can be worked around with stricter VPN config
  - See https://www.bleepingcomputer.com/news/security/new-linux-vulnerability-lets-attackers-hijack-vpn-connections/
- Feature to stack LSM modules is being worked on
  - To enable loading multiple security modules
    - e.g. AppAmour or Tomoyo along with Smack or SELinux
  - See https://lwn.net/Articles/804906/

Security (cont.)

- Kernel Runtime Security Instrumentation
  - Have created a LSM that can run eBPF programs
  - Allows to mitigate a security attack while it's in progress
  - Provides flexible hook for monitoring and mitigation
  - See https://lwn.net/Articles/798157/

Toolchains

- Static analysis framework for GCC
  - Analyses intermediate representation of code
  - Uses a plugin architecture, for now
  - 2 facility categories for now:
    - memory allocation errors
    - file handling errors
  - Adds meta-data to the diagnostic message
    - Lots of information about the problem
    - e.g. Can indicate the Common Weakness Enumeration (CWE) entry for a problem
  - See https://lwn.net/Articles/806099/

Testing

- Kselftest
- Fuego
- KernelCI
- Kunit test framework
- KCIDB project

Kselftest

- Sub-system test code inside kernel source tree
  - Is the preferred place for syscall compatibility/regression tests (over LTP)
- Recent work:
  - More tests and test fixes
    - bpf, spectrum-2, timers, net, netfilter, tls, and more
- See https://lwn.net/Articles/737893
- New Kunit framework added in Linux v5.5

Kunit test framework

- Set of patches for kernel unit testing
  - Accepted in v5.5 (so far)
- Allows writing tests for individual functions
- Tests run in a standalone environment (not in a running kernel) in UML
- https://www.linuxjournal.com/content/unit-testing-linux-kernel
- https://lwn.net/Articles/780985/

Fuego

- Test Framework for collaborating on tests and test infrastructure for Linux
- v1.5 released
- v1.6 in development
  - Improved support for distributed testing
  - Hardware testing
  - Integration with other systems:
    - Ability to run Yocto Project ptest packages
    - First implementation of “test store”

KernelCI

- Support for auto-bisection
- Adding functional tests (not just build and boot)
  - Graphics: IGT (DRM/KMS)
  - Media: v4l2 compliance
  - Power: suspend/resume
  - USB: smoke test
- More on LF project status later

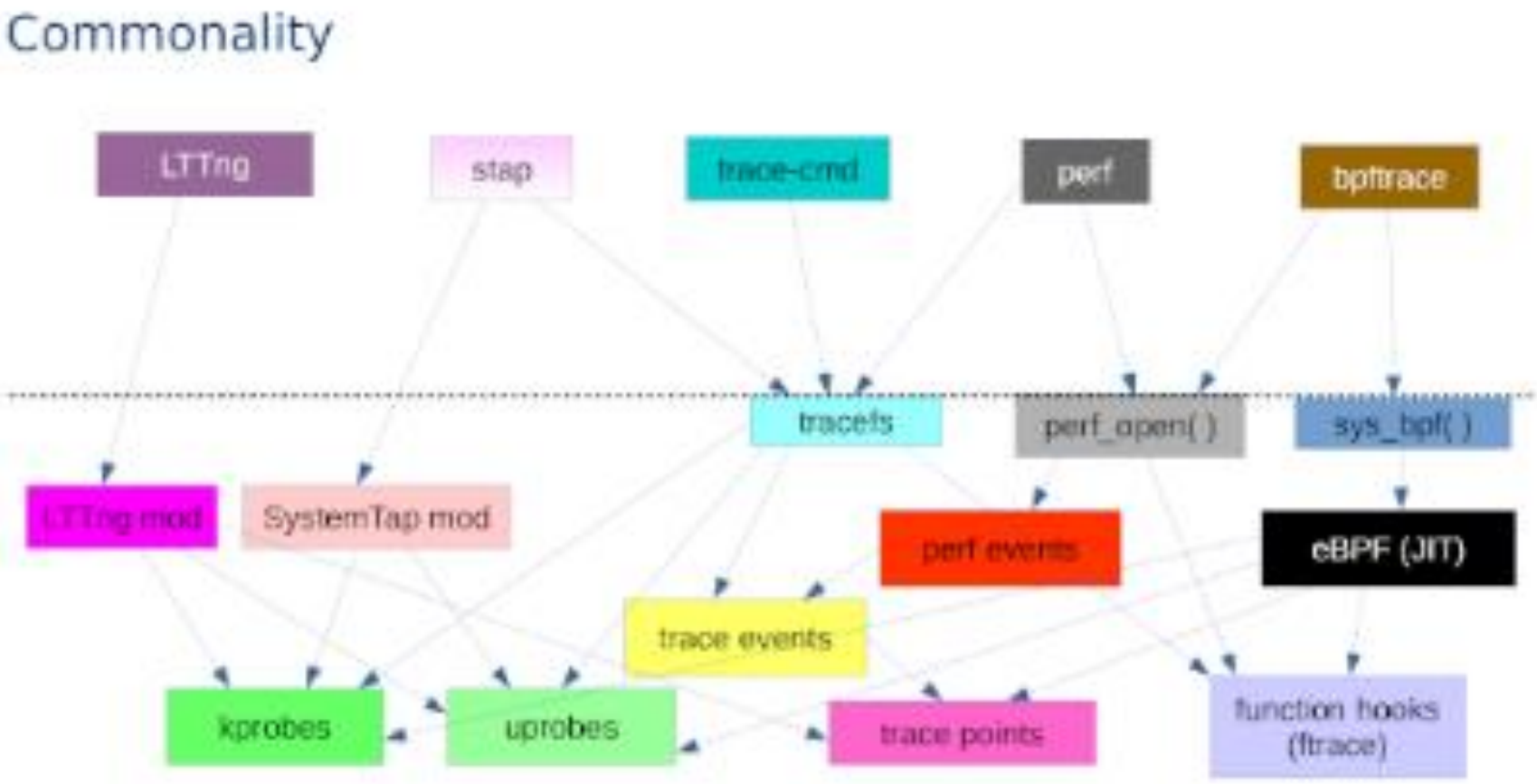
KCIDB

- Idea: Different CI systems report results to a single central results repository
- Uses Google BigQuery cloud database
  - For prototype – could change
- Goal is to come up with a common schema
  - Have a simple one now, not finalized
- Each CI system to write their own client
- Big goal is to consolidate reporting
  - Especially want to support a single bug report to mainline

Tracing

- Good overview of pieces:
  - “Unifying Kernel Tracing” talk by Steve Rostedt at OSSEU 2019
  - See diagram next page
- Talking about providing unifying libraries and commands:
  - Common Trace Format and babeltrace (converter)
  - lib-ification of kernel tracing:
    - libftrace
    - libtrace-cmd
    - libkshark
  - See https://lwn.net/Articles/803347/

Kernel tracing overview



Build systems

- Yocto Project
- Buildroot
- Debian-based builds
  - ISAR
  - meta-debian
  - deby

Yocto Project

- Yocto Project 3.0 release
  - Oct 23, 2019
  - Lots of work on build caching
  - Have new “build change equivalence” feature
    - Have hashes of source and binaries
    - Can detect already-built items, and retrieve them from cache
    - Speeds up build
    - Can share build artifacts using a server
  - Technology lends itself to reproducible builds
  - https://lwn.net/Articles/804640

Buildroot

- New features:
  - LTS release
    - 1 year maintenance for security/bug fixes
  - Git caching
  - Tooling to keep packages up-to-date
    - json output for automation (make show-info)
  - Reproducible builds effort in progress
  - Maintenance tooling improvements
- See ELCE talk: “Buildroot what’s new” by Thomas Petazzoni
  - https://elinux.org/images/c/c5/Petazzoni-buildroot-whats-new-2019.pdf

Outline

Operating Systems
Linux Kernel
Technology Areas
Conferences
Industry News
Resources

Conferences (past)

- Embedded Linux Conference 2019
  - August 21-23, San Diego, California, USA
- Linux Plumbers
  - September 9-11, Lisbon, Portugal
- ELC Europe 2019
  - October 28-30, Lyon, France
- Automated Testing Summit 2019
  - October 31, Lyon, France

ELCE 2019 Report

- Announcements
- Private meetings
- Sessions
- Impressions

LF/ELCE announcements

- Academy Software Foundation (ASWF)
  - New members: Microsoft and Apple
- AGL adds new members
  - Including SAIC motor (China-based car company)
- KernelCI Project (created – more later)
- Open Invention Network (OIN) pivot
  - Change from just patent pooling to also patent defense support for Open Source projects
    - To protect against non-practicing entities (NPEs)
  - See https://www.theregister.co.uk/2019/11/04/open_invention_network_will_pivot_to_take_on_patent_trolls/

ELCE meetings

- Private meetings or conversations I had:
  - Bob Kyeung (ETRI – a South Korean R&D group) has a hypervisor they'd like to publish as open source
  - Thomas Steenbergen (HERE technologies) - is working on upstream licenses fixes and shared license analysis for Open Source projects
  - (unnamed group) – discussions about how to do license compliance notifications for a product with no user interface and no packaging
  - Mattiue Archer (University of Rennes) – discussion about size testing project using AI

ELCE sessions – Mon.

- Debian and YP-based Long-term maintenance approaches for embedded products – Jan Kiszka & Kazuhiro Hayashi
  - Overview of build and test systems for CIP
- NuttX for Embedded Linux Developers - Masayuki Ishikawa
  - Lots of activity by Sony in NuttX
  - Should view this if Linux is too big for your use
- Buildroot: What's new - Thomas Petazzoni
  - (already reported)

ELCE sessions – Mon. (cont.)

- Timing Boot Time Reduction Techniques - Michael Opdenacker
  - Great session with numbers for each technique
    - Also had good size reduction info
      - Size and boot time are often related
    - If doing boot time reduction, should definitely watch
  - My thought: Someone should add this content to the wiki
- BOF: Challenges of Low Spec Embedded Linux - Alexander Sack
  - Some ideas kicked around. Nothing very new.

ELCE sessions – Tues.

- Activities of the Super Long Term Support Kernel Workgroup in CIP Project - SZ Lin & Pavel Machek
  - Very interesting introduction to/by the poor souls who are tasked with super long term support
- Experience Building a Local Open Source Community via the OpenChain project - Hiroyuki Fukuchi
  - Good presentation on community-building
  - Also discussion of supply-chain compliance issues

ELCE sessions – Tues. (cont)

- Academy Software Foundation... – Guy Martin
  - A nice status update on AWSF work
  - New members, new projects, off to a good start
  - Funding level over 1 million per year
- Stress testing and microBenchmarking with Stress-ng – Colin Ian King
  - Very thorough and usable stress testing program
    - Over 220 stressors
  - Portable and flexible
  - My thought: I should add this to Fuego

ELCE sessions – Wed.

- Debian or Yocto Project? Which is Best for your Embedded Linux Project - Chris Simmonds
  - It depends on various factors (see talk and video)
- The Static Check Needle in the Warnings Haystack - Frank Rowand
  - New tool to find new warnings that a patch introduces into the kernel build
  - My takeaway: It's interesting that there is still fundamental tooling that can be done to improve kernel development
- Closing game - Tim Bird
  - A fun game (and my platform for a message)

ELCE impressions

- Hot topics:
  - Top submission topics:
    - security, test, Yocto Project
    - tools, build, network, debug
  - These are “meta-topics”
  - Still lots of code-related topics
- Tools and techniques for license management and compliance seem to be maturing
- Still lots of enthusiasm for basic topics
  - Embedded Linux Apprentice talks were popular

ATS 2019 Report

- Overview
  - 50 people, Oct 31, Lyon, France
  - Lots of good presentations – 2 tracks
  - Fragmentation of test frameworks is a big problem
- Key decisions
  - Focus on KCIDB (for results)
  - Try using LTP meta-data format in other projects
  - Continue test hardware “best practices” document
- See https://lwn.net/Articles/804050/
- and https://elinux.org/Automated_Testing_Summit_2019

Conferences - 2020

- Embedded Linux Conference 2020
  - June 22-24, Austin, Texas, USA
- Linux Plumbers
  - August 28, Halifax, Canada
- Open Source Summit Japan
  - September 15-16, Tokyo, Japan
- ELC Europe 2020
  - October 26-28, Dublin, Ireland

Outline

Operating Systems
Linux Kernel
Technology Areas
Conferences
Industry News
Resources

Industry News

- Trade associations
- Miscellaneous news

Trade associations

- Linux Foundation
  - KernelCI project

KernelCI project

- KernelCI was announced as an official project of the Linux Foundation
- Founders:
  - Google, RedHat, Microsoft, Collabora, BayLibre, Civil Infrastructure Project, Foundries.io
- Focused on upstream testing
- Still waiting to see what the project will actually do
  - Hosting for new kcidb project?
  - Funded kernelci development?
  - Standards work?

Miscellaneous News

- Gnome Foundation attacked by patent NPE
- Python security attacks
- Gitlab policy change results in backlash
- Kernel workflow improvement
  - https://lwn.net/Articles/803619/ (Marta R.)

Gnome Foundation sued by patent NPE (troll)

- Rothschild sued Gnome Foundation
  - Claims that “Shotwell” image management app infringes a patent
  - Patent is very generic
    - Uploading images over a wireless network using a filter criteria (e.g. subject identification)
- Gnome foundation is fighting back
  - Established a legal defense fund
    - With a fundraising goal that was quickly met
- OIN has suggested that they will help
- See https://www.zdnet.com/article/leave-gnome-alone-this-patent-troll-is-asking-for-trouble/

Python security attacks

- Used typosquatting to try to inject malicious modules into the python ecosystem
  - “jellyfish” module vs “jellyfish” (first ‘L’ is an ‘I’)
- Extra code to extract SSH and GPG keys
- Available in PyPI module repository for 1 year
- Finally caught when another malicious module was introduced that referenced it
  - “python3-dateutil” vs “dateutil”
- Should be careful using external code
- See https://www.zdnet.com/article/two-malicious-python-libraries-removed-from-pypi/

Gitlab policy change

- Gitlab company made a change to their policy for gathering data on users
  - To support plugins for data collection on customer usage
  - For themselves and 3rd parties
- There was a big backlash
  - Including calls for a vice president to be fired
- Gitlab retracted the policy and apologized
- See https://reclaimthenet.org/gitlab-backtracks-on-tracking/

Kernel workflow improvements

- Proposal to:
  - Add patch attestation
  - Add base tree to submitted patches
  - Git-to-email bridge
  - Create patch feeds, with meta-data
    - Successor to patchwork?
- Lots of discussion about proposals and alternatives
- Maybe funding by Linux Foundation
- See https://lwn.net/Articles/803619/

Outline

Operating Systems
Linux Kernel
Technology Areas
Conferences
Industry News
Resources

Resources

- LWN.net – https://lwn.net
  - If you are not subscribed, please do so
  - Some content is delayed by 2 weeks for non-subscribers (some links in this presentation)
- Linux.com – https://linux.com
- Linux Gizmos – https://linuxgizmos.com
- Linux Journal – https://www.linuxjournal.com/
- Phoronix - https://www.phoronix.com/
- Google
- eLinux wiki - http://elinux.org/ (next page)

Resources

- https://elinux.org/ELC_Presentations

Page Discussion Read Edit View history More Search eLinux.org

ELC Europe 2019 Presentations

Contents [show]

Intro [edit]

Presentations from https://events19.linuxfoundation.org/events/embedded-linux-conference-europe-2019/ ELCE 2019 (LF conference archive)].

Some additional videos, such as keynotes, are available at the Linux Foundation YouTube playlist.

NOTE: If you add a wikilink to your presentation and attempt to upload it via the link, it may fail. If it does, use the Special:Upload page to upload your file.

Presenters [edit]

Day 1 Presentations [edit]

Session Description	Presenter(s)	Presentation	Transcript Status	Video
Day 1, 11:30am				
Debian and Yocto Project Based Long-Term Maintenance Approaches for Embedded Products	Kazuhiro Hayashi, Toshiba & Jan Kiszka, Siemens AG	PDF		Video
PMIC: First One to Turn On and Last One to Turn Off	Keerthy Jagadeesh, Texas Instruments	PDF		Video
V4L2: A Status Update	Hans Verkuil, Cisco Systems Norway	PDF		Video
Day 1, 12:20pm				
Everything Great about Upstream Graphics	Daniel Vetter, Intel	PDF		Video
Fully Automated Power Measurement Solution Coupled with IC Temperature Control	Jerome Neanne, BayLibre & Pascal Mareau, NXP	PDF		Video
Multicore Application Development with Zephyr RTOS	Alexey Brodkin, Synopsys	PDF		Video
NuttX for Embedded Linux Developers	Masayuki Ishikawa, Sony	PDF		Video

Thanks!